BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a toning station employed in electrophotographic printers and copiers. More particularly, this invention relates to a bearing cap and tension assembly used to increase the toning shell speed, and to toning stations and electrophotographic printers including such a bearing cap and tension assembly.

2. Brief Description of the Related Art

Throughout this disclosure, the term "electrophotographic printer" is to be construed to include both printers and copiers employing electrophotographic means for image production. Electrophotographic printers that utilize a dry ink toner-based developer include a developer station having a rotating toning shell that is used to transport the developer mix to the site where the toner is applied to a photoconductor that carries an electrostatic image. The toner interacts electrostatically with the photoconductor, temporarily bonding to the photoconductor before being transferred to the paper.

In some situations, however, the toner is not applied evenly to the photoconductor, resulting in a density "spike" on the leading edge of the paper. In other words, the toner is applied more heavily at the leading edge of the page than it is on the rest of the page, leading to possible image quality problems, especially at higher page-per-minute output speeds. As disclosed in U.S. Patent Application Serial No. 60/204,882, incorporated herein by reference, this leading edge density problem may be overcome by increasing the rotational speed of the toning shell beyond the speed at which the toning shell rotates on some currently available printers. Therefore, a need exists in the art for an electrophotographic printer having a toning shell capable of rotating at higher speeds than are attainable with some currently available printers.

Typically, the toning shell is driven by means of a chain driven by a sprocket affixed to a shaft that ultimately is driven through a gear box actuated by the main drive motor of the copier. In certain prior art printers, the toning shell was driven directly by a shaft through a single drive chain, with a sprocket mounted on the shaft and a second

sprocket mounted on the toning shell. Given the space constraints of the internal volume of many current printers, it is not feasible to simply affix a larger sprocket to the drive shaft, as such a sprocket large enough to generate the required toning shell speed would not fit within the available space. Similarly, it is not feasible to substitute a smaller drive gear on the toning shell shaft, as such a sprocket would necessarily have a smaller diameter than the shaft on which it would be carried, in order to achieve the necessary speeds.

Accordingly, it is an object of the present invention to provide an electrophotographic printer having a toning shell capable of rotating at higher speeds than currently available printers, without substantially re-designing the interior of the printer. In other words, it is an object of this invention to meet the need for increased toning shell speeds within the design constraints imposed by the physical makeup of some current electrophotographic printers.

Moreover, because toner is incompatible with lubrication oils, the drive chains used in electrophotographic printers are typically oiled lightly during manufacture and are then generally not oiled again during their useful life. As a result, the drive chain exhibits wear over time, typified by a slack in the chain. Therefore, it is preferable to include some form of chain tensioner to maintain appropriate chain tension, despite chain wear. Positioning of the tensioner is, however, difficult, in view of the need for the entire toner assembly to move for purposes of adjustment of the individual components of the toning station relative to each other to accomplish optimal transfer of developer through the toning station. This situation is addressed in U.S. Patent Application 09/442,303, incorporated herein by reference. When the toner assembly is adjusted, the tensioner must also be adjusted, largely defeating the purpose of the tensioner. Accordingly, there is a need in the art for a chain tensioning assembly that does not require adjustment each time the toning station components are adjusted relative to each other.

Thus it is a further object of this invention to provide an integral toning station bearing and tensioning assembly that provides tension to a drive chain without interfering with the movement of the toning station components that must be moved for necessary adjustments.

SUMMARY OF THE INVENTION

The present invention solves these and other shortcomings of the prior art by utilizing a faster blender shaft speed and reducing it with sprocket tooth and chain combinations, allows for additional multiplication of the speed of the toning shell without resorting to overly large or small drive sprockets. Additionally, the invention includes an intermediate bearing cap having an integral tensioning sprocket to maintain appropriate chain tension despite chain wear. Because the integral tensioner moves with the bearing cap, no separate adjustment of the tensioner is necessary after toning station adjustment.

In one embodiment, the invention is a bearing cap assembly, including a bearing cap housing, containing at least one bearing, and a tension sprocket assembly secured to the bearing cap housing. In a preferred embodiment, the tension sprocket assembly includes a tension sprocket mounted on a shaft, the shaft secured to a backplate, where the backplate is secured in a channel in the bearing cap body, such that the backplate may move along the channel to provide tensioning pressure to a chain passing over the tension sprocket, and where the tension assembly is biased against the drive chain.

In another embodiment, the invention is an electrophotographic printer having a high speed toning shell. The toning station includes a toner blender, a toner bucket and a toning shell, where the toner blender driven by a blender drive shaft and the toner bucket driven by a bucket drive shaft. A first intermediate drive sprocket is affixed to the blender drive shaft such that rotation of the blender drive shaft directly causes rotation of the first intermediate drive sprocket. A second intermediate drive sprocket is affixed to the bucket drive shaft to permit free rotation of the second intermediate drive sprocket relative to the bucket drive shaft, and an intermediate drive chain connects the first and second intermediate drive sprockets, wherein the second intermediate drive sprocket has a larger diameter than the first intermediate drive sprocket. A first primary drive sprocket is affixed to the second intermediate drive sprocket, such that rotation of the second intermediate drive sprocket directly causes rotation of the first primary drive sprocket, and a second primary drive sprocket is affixed to the toning shell. A primary drive chain connects the first and second primary drive sprockets, wherein the first primary drive sprocket has a smaller diameter than the second primary drive sprocket.

In a preferred embodiment, the electrophotographic printer further includes a tension sprocket assembly to maintain tension on the intermediate drive chain. In one embodiment, the tension sprocket assembly includes a tension sprocket that is biased against the intermediate drive chain to exert tensioning pressure on the intermediate drive chain. The tension sprocket is mounted on a shaft having an axis, the shaft secured to a backplate, and the backplate is secured in a channel in the bearing cap body, such that the backplate may move along the channel to provide tension to a chain passing over the tension sprocket. A spring biases the tension assembly against the drive chain.

In another embodiment, the invention is an electrophotographic developing station having a high speed toning shell, including a toner blender, a toner bucket and a toning shell, where the toner blender is driven by a blender drive shaft, and the toner bucket is driven by a bucket drive shaft. A first intermediate drive sprocket is affixed to the blender drive shaft such that rotation of the blender drive shaft directly causes rotation of the first intermediate drive sprocket. A second intermediate drive sprocket is affixed to the bucket drive shaft to permit free rotation of the second intermediate drive sprocket relative to the bucket drive shaft, and an intermediate drive chain connects the first and second intermediate drive sprockets, wherein the second intermediate drive sprocket has a larger diameter than the first intermediate drive sprocket. A first primary drive sprocket is affixed to the second intermediate drive sprocket, such that rotation of the second intermediate drive sprocket directly causes rotation of the first primary drive sprocket. A second primary drive sprocket affixed to the toning shell, and a primary drive chain connects the first and second primary drive sprockets. The first primary drive sprocket has a smaller diameter than the second primary drive sprocket.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a side view of a toning station of the present invention.

FIG. 1B is a partial cross-sectional view of the toning station, with the intermediate drive chain and sprockets removed to show the primary drive chain and sprockets.

FIG. 2 is cross-sectional view of the toning station taken along line 2 – 2.

FIG. 3 is a side view of a unitary bearing cap and integral tension sprocket assembly.

FIG. 4 is a cross-sectional view taken along line 4 – 4.

DETAILED DESCRIPTION OF THE DRAWINGS AND PREFERRED EMBODIMENTS

Referring to Figs. 1A, 1B and 2, a typical toning station **10** of the type employing the present invention includes a developer blender **12** and a developer delivery bucket **14**. Toner is delivered to the blender **12** through a toner replenisher (not shown), and is mixed in the blender **12** with a particulate carrier to yield a two-component developer. The blended developer spills over into the bucket **14**, and the bucket rotates to deliver developer to the toning shell **16**. A toner monitor (not shown) measures the amount of toner in the developer mix and, in the event the proportion of toner falls below a minimum amount, a toner replenisher (not shown) is actuated to deliver additional toner to the blender **12** through toner supply site **15**. The toner monitor must be positioned within a narrow tolerance between the blender **12** and the delivery bucket **14** and, therefore, it is necessary to occasionally shift the blender **12** and developer delivery bucket **14** to re-establish the appropriate position relative to the toner monitor.

The blender **12** is driven by a blender shaft **18** that passes through the blender **12** axially, and is ultimately driven through a gear box connected to the main drive motor of the printer (not shown). Affixed to an end of the blender shaft **18** is a first intermediate drive sprocket **20**. Likewise, the bucket **14** is driven by an axial bucket shaft **22**. A second intermediate drive sprocket **24** rotates on a needle bearing **26** relative to an auxiliary bucket shaft **25**, which is press fit into an end of the bucket shaft **22**. The needle bearing **26** is seated in a recess in the sprockets **24, 30**, and rides on the auxiliary bucket shaft **25**. Thus, the second intermediate drive sprocket **24** is not driven by the bucket shaft **22**, but rather merely idles on the auxiliary bucket shaft **25** and is driven by an intermediate drive chain **28** that passes around and over the first and second intermediate

drive sprockets **20, 24**. Accordingly, the rotation of the first intermediate drive sprocket **20**, imparted by the blender shaft **18**, is transmitted to the second intermediate drive sprocket **24** by the intermediate drive chain **28**. As shown in Fig. 1, the second intermediate drive sprocket **24** is significantly larger in diameter than the first intermediate drive sprocket **20**. In a preferred embodiment, the sprocket ratio for the intermediate drive sprockets is 6:11, although other ratios are appropriate and included within the scope of this invention.

The intermediate drive chain **28** is tensioned by an intermediate tension sprocket assembly **31**, that includes an intermediate tension sprocket **21**, supported on an intermediate tension sprocket shaft **23**. As discussed in more detail below, the intermediate tension sprocket **21** is biased laterally with respect to the intermediate drive chain **28** to absorb any slack that develops as the chain **28** wears, maintaining appropriate tension on the chain **28**.

A primary drive sprocket **30** is affixed to the second intermediate drive sprocket **24**, and, therefore, the second intermediate drive sprocket **24** directly drives the primary drive sprocket **30**. The primary drive sprocket **30** drives a toning shell drive sprocket **32** by means of a primary drive chain **34**. The primary drive sprocket **30** is smaller in diameter than the toning shell sprocket **32**. In a preferred embodiment, the sprocket ratio of the primary drive sprocket **30** and the toning shell sprocket **32** is 2:3, although other ratios appropriate and included in the scope of this invention. The primary drive chain **34** is tensioned by a primary tension sprocket **36** affixed to a tension arm assembly **38**, which is biased by an idler tension spring **40**.

Thus, referring also to Fig. 3, the toning shell **16** is driven by toning shell drive sprocket **32**, which is driven by the primary drive sprocket **30** through primary drive chain **34**. The primary drive sprocket **30** is driven by the second intermediate drive sprocket **24**, which is driven by the first intermediate drive sprocket **20**, through intermediate drive chain **28**. The first intermediate drive sprocket **20** is driven directly by the blender shaft **18**.

In a preferred embodiment, the locations of the drive sprockets **20, 24, 30** and the intermediate tension assembly **31** are maintained by a unitary bearing cap and tensioner assembly **50**. The bearing cap assembly **50** includes bearing cap body **52**, a blender

bearing **42** and a bucket bearing **44**, that carry, respectively, the blender shaft **18** and the auxiliary bucket shaft **25**. The bearing cap body **52** includes mounting brackets **54** defining apertures **55** to accept bolts or similar fasteners that affix the bearing cap **50** to the face of the blender **12** and the bucket **14**.

The bearing cap body **52** defines a channel **56** that receives and retains an intermediate tensioner backplate **58**. The intermediate tensioner shaft **23** is affixed to the backplate **58**. The backplate **58** is slidably retained in channel **56**, such that the backplate **58** and, thus, the intermediate tension shaft **23** and intermediate tension sprocket **21** are able to slide along the length of the channel, thus moving the intermediate tension sprocket **21** across the face of the bearing cap **50**.

The backplate **58** is biased against the intermediate drive chain **28**, such that when the intermediate drive chain **28** passes under the first and second intermediate drive sprockets **20, 24** and over the intermediate tension sprocket **21**, the intermediate drive chain **28** is tightened, while ensuring that the intermediate drive chain **28** remains in contact with the intermediate drive sprockets **20, 24**. In a preferred embodiment, the backplate **58** is biased against the drive chain by a spring **60**, although other arrangements will be apparent to those skilled in the art.

It is to be understood that the foregoing detailed description describes presently preferred embodiments of the invention and that other alternatives, which will become apparent to those of skill in the art upon reviewing the foregoing description, are likewise intended to fall within the scope of the appended claims, including equivalents thereto.